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# Achievement emotions among adolescents receiving special education support in mathematics☆

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ABSTRACT

This study investigated mathematics-related achievement emotions among Finnish adolescents ($N$ = 1379) receiving special education support (SEdS) in self-contained and general mathematics classrooms and receiving no mathematics SEdS through multilevel modeling. Mathematics performance, gender, and classroom size were controlled for. Adolescents receiving SEdS in general classrooms reported less enjoyment and pride and more anger, anxiety, shame, hopelessness, and boredom than those receiving SEdS in self-contained classrooms and those receiving no SEdS. In contrast, adolescents receiving SEdS in self-contained classrooms reported more enjoyment and pride and less anger, anxiety, and hopelessness than those receiving no SEdS. Furthermore, adolescents receiving no SEdS reported more anxiety, hopelessness, and boredom in general classrooms when the proportion of classmates receiving SEdS was higher. We discuss the practical implications for developing SEdS in relation to achievement emotions.

## 1. Introduction

From the political and educational perspectives, there is a growing worldwide movement toward inclusion, whereby students requiring special education support (SEdS) are served in general classrooms (UNESCO, 2009). Thus, a central aim is to identify the benefits and disadvantages of serving students in general education instead of in separate self-contained classrooms (Ruijs & Peetsma, 2009). Investigating achievement emotions in SEdS settings helps understand this issue from an emotional perspective. Achievement emotions related to academic outcomes and activities are worth investigating because in classrooms they guide adolescents' learning and affect their achievement and well-being (Pekrun, 2017). Investigating such emotions among adolescents in general and self-contained classrooms can help educators to understand and support their learning, achievement, and well-being.

Although placing students receiving SEdS in general classrooms might benefit their academic performance (Ruijs & Peetsma, 2009), placing them in self-contained classrooms might benefit their affective outcomes, such as enjoyment and self-concept (Kocaj, Kuhl, Jansen, Pant, & Stanat, 2018; Szumski & Karwowski, 2015). However, research on the achievement emotions of students receiving SEdS is scarce (Kocaj et al., 2018; Wiest, Wong, Cervantes, Craik, & Kreil, 2001). Researchers have suggested that students receiving SEdS in general classrooms are socially integrated (e.g., interaction with peers and reduced SEdS-related stigma), while those in self-contained classrooms receive personal teacher support (Hannes, Von Arx, Christiaens, Heyvaert, & Petry, 2012; Myklebust, 2007; Ruijs & Peetsma, 2009). As teacher support is associated with adolescents' pleasant achievement emotions (Sakiz, Pape, & Hoy, 2012), adolescents receiving SEdS in self-contained classrooms might experience pleasant achievement emotions. Furthermore, students receiving SEdS in general classrooms might compare themselves with higher-performing classmates, while those in self-contained classrooms might compare themselves with lower-performing classmates (Ruijs & Peetsma, 2009). The big-fish-little-pond effect (BFLPE) indicates that a higher class-average performance has a negative effect on students' affective outcomes because students compare their performance with that of their higher-performing classmates (Marsh et al., 2008). According to the BFLPE (Pekrun, Murayama, Marsh, Goetz, & Frenzel, 2019), this social comparison might cause adolescents receiving SEdS in self-contained classrooms to experience more mathematics-related enjoyment and pride and less anger, anxiety, shame, and hopelessness than those receiving SEdS in general classrooms.

Another topic is whether the proportion of students receiving SEdS in

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general classrooms is related to achievement emotions of students receiving no SEdS. Instead of achievement emotions, research has shown that the presence of students receiving SEdS in general classrooms mostly has positive effects on social relationships (e.g., understanding individual differences; Ruijs & Peetsma, 2009) and mixed effects on academic performance of classmates receiving no SEdS (Hienonen, Lintuvuori, Jahnukainen, Hotulainen, & Vainikainen, 2018; Szumski, Smogorzewska, & Karwowski, 2017). However, the negative effect on academic performance was evident among adolescents (Dyson, Farrell, Polat, Hutcheson, & Gallannaugh, 2004; Hienonen et al., 2018). Researchers have also suggested that the presence of students receiving SEdS in classrooms decreases teachers' support (Dyson et al., 2004) and learning demands (e.g., is unchallenging) for students receiving no SEdS (Ruijs, Van der Veen, & Peetsma, 2010). Because the decreased support and learning demands might relate to unpleasant achievement emotions (Pekrun, 2006), the higher proportion of students receiving SEdS in general classrooms might be associated with unpleasant achievement emotions of adolescents receiving no SEdS.

We focus on achievement emotions and SEdS in mathematics because achievement emotions are organized in subject-specific ways (Goetz, Frenzel, Pekrun, Hall, & Lüdtke, 2007). Understanding mathematics-related achievement emotions in SEdS settings helps support achievement emotions of adolescents with mathematics difficulties and in turn, improves their mathematics performance (Pekrun, Lichtenfeld, Marsh, Murayama, & Goetz, 2017). Adolescents with mathematics difficulties might be at a greater risk of dropping out of school than those with reading difficulties (Hakkarainen, Holopainen, & Savolainen, 2015). Supporting adolescents' achievement emotions might decrease this risk (Respondek, Seufert, Stupnisky, & Nett, 2017). Therefore, we examined such emotions among adolescents receiving SEdS in general or self-contained mathematics classrooms. We also investigated whether the proportion of adolescents receiving SEdS in general classrooms has a contextual effect on mathematics-related emotions of classmates receiving no SEdS. Such a contextual effect (Marsh et al., 2009) would mean that classroom-level characteristics (e.g., aggregation or composition of individual-level characteristics) are related to individual outcomes, such as emotions, beyond what can be explained by individual characteristics.

### 1.1. SEdS in mathematics

In Finland, student eligibility for SEdS is based on multiprofessional evaluations, including the views of teachers, special education teachers, and parents (Björn, Aro, Koponen, Fuchs, & Fuchs, 2016; Finnish National Board of Education [FNBE], 2004, 2016). Mathematics difficulties are the most common reason for SEdS in Finnish lower secondary schools, followed by language difficulties (Statistics Finland, 2011). All students might receive occasional general support (Tier 1[1]; Björn et al., 2016; FNBE, 2004, 2016), which is not considered SEdS.

Students with mild difficulties in mathematics might receive part-time SEdS (Tier 2) in small groups in resource rooms for 1 or 2 h per week and through coteaching in general classrooms (FNBE, 2004, 2016; Graham & Jahnukainen, 2011). These students are supported in the general education context by special education teachers, who collaborate with general mathematics teachers (FNBE, 2004, 2016). Part-time SEdS seems to be most common in Finnish lower secondary schools (Grades 7 to 9) and is most prevalent in mathematics (Statistics Finland, 2011). In lower secondary schools, approximately 17% of the students receive part-time SEdS in general, and approximately 6% receive it in mathematics (Statistics Finland, 2011).

If part-time SEdS cannot meet the needs of students with more substantial mathematics difficulties, they receive full-time SEdS (Tier 3), with an individualized education plan (IEP; FNBE, 2004, 2016). These students can be integrated into general mathematics classrooms, where special education teachers provide additional support for them, such as coteaching, in collaboration with mathematics teachers (FNBE, 2004, 2016). Alternatively, students with substantial mathematics difficulties might receive full-time SEdS from special education teachers in small, separate self-contained mathematics classrooms (Björn et al., 2016; FNBE, 2004, 2016). In other subjects, these students are integrated into general classrooms or study in separate self-contained classrooms. About 2.7% of lower secondary school students receive full-time SEdS in general classrooms, while approximately 6% of them receive full-time SEdS in some subjects in self-contained classrooms (Statistics Finland, 2011).

We focused on adolescents with mathematics difficulties receiving part-time (Tier 2) or full-time SEdS (Tier 3) in general mathematics classrooms or full-time SEdS (Tier 3) in self-contained mathematics classrooms.

### 1.2. Achievement emotions

Among several theories of emotions (Hascher, 2010; Weiner, 2014), we have chosen the control-value theory (Pekrun, 2006) because it offers an integrative framework of the emotional theories for analyzing achievement emotions (e.g., enjoyment and anger) and their relationship to academic outcomes. Based on this theory, achievement emotions are divided into activity-related emotions experienced in relation to academic activities (e.g., boredom during homework) and outcome-related emotions experienced before or after academic outcomes, such as success or failure (e.g., pride after a successful exam). These emotions are classified as typically experienced in certain situations (i.e., trait emotions) or momentarily experienced in specific situations at particular times (i.e., state emotions; Pekrun, 2006). The control-value theory specifies that classroom mechanisms (e.g., task demands, support, goals, feedback, and instruction) are related to achievement emotions. Specifically, classroom mechanisms influence individuals' control (e.g., competence) and value (e.g., importance) appraisals, which, in turn, affect their achievement emotions. Thus, the classroom environment should be considered when investigating achievement emotions.

Because achievement emotions are organized in subject-specific ways, assessments have been developed to measure mathematics-related achievement emotions (Pekrun, Goetz, & Frenzel, 2005). Research has shown that value and control appraisals, self-concept, and mathematics performance are associated with mathematics-related emotions (Buff, 2014; Holm, Hannula, & Björn, 2017; Pekrun et al., 2017; Van der Beek, Van der Ven, Kroesbergen, & Leseman, 2017). However, research has increasingly shown that classroom mechanisms such as teacher support (e.g., helpfulness) are associated with adolescents' pleasant mathematics-related emotions, such as enjoyment and lower anxiety and hopelessness (Ahmed, Minnaert, van der Werf, & Kuyper, 2010; Lazarides & Buchholzb, 2019; Sakiz et al., 2012). Thus, SEdS settings might be associated with adolescents' mathematics-related emotions.

### 1.3. Relations between emotions and SEdS

It is an open question to what extent adolescents receiving SEdS in mathematics experience mathematics-related achievement emotions. Some studies have investigated achievement emotions of students receiving SEdS (Kocaj et al., 2018; Wiest et al., 2001). Kocaj et al. (2018) found that primary school students receiving SEdS in self-contained classrooms in special schools reported more enjoyment than those receiving SEdS in general classrooms. Wiest et al. (2001) found that adolescents receiving SEdS in self-contained classrooms reported less anxiety than peers receiving no SEdS. Because research on achievement emotions is scarce, we briefly present similar findings of affective

[1] Since our data were collected, the SEdS framework has been implemented (Finnish Basic Education Act, 2010). This framework recalls the United States' response to intervention, divided into three tiers of support (Björn et al., 2016; FNBE, 2016).

outcomes other than emotions. Adolescents receiving SEdS in general classrooms reported less intrapersonal strength (e.g., enthusiasm for life; Lappalainen, Savolainen, Kuorelahti, & Epstein, 2009) and more depression (e.g., everything went wrong; Valås, 2001) than adolescents receiving no SEdS. Moreover, SEdS in general mathematics classrooms did not improve students' mathematics-related self-concept compared to students receiving no SEdS (Savolainen, Timmermans, & Savolainen, 2018). Primary school children receiving SEdS in self-contained classrooms had a higher mathematics self-concept than those receiving SEdS in general classrooms (Kocaj et al., 2018). Because self-concept is associated with pleasant achievement emotions according to the control-value theory (Pekrun, 2006), adolescents receiving SEdS in self-contained classrooms might experience more pleasant mathematics-related emotions than those receiving SEdS in general classrooms.

Multilevel analyses showed that the effect of classroom-level characteristics on individuals' achievement emotions should be investigated (the contextual effect; Baudoin & Galand, 2017; Frenzel, Pekrun, & Goetz, 2007; Pekrun et al., 2019). These studies showed that gender proportions (Frenzel et al., 2007) and class-average mathematics achievement (BLFPE; Pekrun et al., 2019) have contextual effects on adolescents' mathematics-related achievement emotions as they compared themselves with boys and higher-performing classmates. Some findings of multilevel analysis suggested that the contextual effect might be found in relation to SEdS (Dyson et al., 2004; Hienonen et al., 2018). These studies showed that the proportion of adolescents receiving SEdS in general classrooms has a negative contextual effect on the academic performance of adolescents receiving no SEdS. Researchers have identified three possible mechanisms (i.e., learning, teacher support, and peer support) that could explain why students receiving no SEdS experience unpleasant achievement emotions when the proportion of students receiving SEdS in general classrooms is higher. First, primary school students receiving no SEdS reported in interviews being taught too slowly and learning less in inclusive classrooms and, thus, reported boredom (Litvack, Ritchie, & Shore, 2011; Vaughn, Schumm, Klingner, & Saumell, 1995). The control-value theory states that boredom is related to unchallenging activities (Pekrun, 2006). Second, teachers might focus on students receiving SEdS in general classrooms, forcing students receiving no SEdS to study without support (Dyson et al., 2004; Ruijs et al., 2010). Studying without teacher support may decrease adolescents' enjoyment and increase their anxiety and hopelessness (Ahmed et al., 2010; Sakiz et al., 2012). Third, students receiving no SEdS might receive less peer support when the proportion of lower-performing students receiving SEdS is higher in classrooms; thus, they may experience less enjoyment (Ahmed et al., 2010; Kocaj et al., 2018).

### 1.4. The present study

Previous studies found that students receiving SEdS in self-contained classrooms reported less enjoyment and higher self-concept than those receiving SEdS in general classrooms (Kocaj et al., 2018) and less anxiety than those receiving no SEdS (Wiest et al., 2001). Contrarily, adolescents receiving SEdS in general classrooms reported more depression and less intrapersonal strength than those receiving no SEdS (Lappalainen et al., 2009; Valås, 2001). However, we lack knowledge about whether these differences exist for several achievement emotions. Studies have shown that students receiving no SEdS reported boredom in inclusive classrooms (Litvack et al., 2011; Vaughn et al., 1995) and that the proportion of adolescents receiving SEdS in general classrooms has a negative contextual effect on the academic performance of adolescents receiving no SEdS (Hienonen et al., 2018). Hence, investigating this contextual effect on several achievement emotions is important.

We investigated mathematics-related enjoyment, pride, anger, boredom, anxiety, hopelessness, and shame of adolescents with mathematics difficulties and receiving SEdS in mathematics. We investigated habitual trait achievement emotions rather than momentary state achievement emotions because trait emotions can influence well-being over a long period (Pekrun, 2006) and, thus, might be important for the well-being of adolescents receiving SEdS. We controlled for mathematics performance and gender at the individual and classroom levels because previous studies have shown that these variables are associated with such emotions at both levels (Frenzel et al., 2007; Pekrun et al., 2019). We controlled for class size at the classroom level, as it varied in this study and because larger class size is related to negative achievement emotions, such as anxiety (Khajavy, MacIntyre, & Barabadi, 2018). We addressed the following research questions (RQs).

**RQ1**. Do adolescents receiving SEdS in self-contained mathematics classrooms differ in mathematics-related achievement emotions from those receiving mathematics SEdS in general classrooms and from those receiving no SEdS? Those receiving no SEdS were in general classrooms with and without adolescents receiving SEdS. Based on the literature (Kocaj et al., 2018; Szumski & Karwowski, 2015), we hypothesized that adolescents receiving SEdS in self-contained classrooms report more pleasant mathematics-related emotions, such as enjoyment, than adolescents receiving SEdS in general classrooms (H1). Based on Wiest et al.'s (2001) study, we hypothesized that adolescents receiving SEdS in self-contained classrooms report less mathematics-related anxiety than those receiving no SEdS (H2). Mechanisms such as comparison with lower-performing classmates and personal teacher support in self-contained classrooms support H1 and H2 (Myklebust, 2007; Pekrun et al., 2019; Sakiz et al., 2012).

**RQ2.** Do adolescents receiving SEdS in general mathematics classrooms differ in mathematics-related achievement emotions from those receiving no mathematics SEdS (in classrooms with and without students receiving SEdS)? Based on the literature (Lappalainen et al., 2009; Valås, 2001), we hypothesized that adolescents receiving SEdS in general classrooms report more mathematics-related unpleasant emotions than those receiving no SEdS (H3). Mechanisms such as comparison with higher-performing classmates and low personal support in general classrooms support H3 (Myklebust, 2007; Pekrun et al., 2019; Sakiz et al., 2012).

**RQ3.** Is the proportion of adolescents receiving SEdS in general mathematics classrooms associated with mathematics-related emotions of adolescents receiving no SEdS? The presence of students receiving SEdS in classrooms might decrease learning demands and teacher and peer support of students receiving no SEdS (Kocaj et al., 2018; Litvack et al., 2011; Ruijs et al., 2010). The first mechanism might increase boredom of students receiving no SEdS (Litvack et al., 2011; Pekrun, 2006; Vaughn et al., 1995). Thus, we hypothesized that the higher proportion of adolescents receiving SEdS in general classrooms has a contextual effect on boredom of adolescents receiving no SEdS (H4).

## 2. Method

### 2.1. Participants

The sample comprised eighth-grade participants (14–15 years old) from all five Finnish provinces. The Finnish educational system consists of 6 years of primary school and 3 years of lower secondary school. Most children begin school at age 7. The present data came from a large survey, and some of the data were used in previously published studies (Holm et al., 2017; Holm et al., 2018). These previous studies indicated that achievement emotions and executive functions are strongly linked to mathematics performance. However, this study represents a substantial contribution because it was the first to investigate several achievement emotions in SEdS settings.

We used clustering, stratified, and systematic sampling methods (Lehtonen & Pahkinen, 2004) to obtain a geographically representative sample. The school sample was drawn from the statistical list of Finnish compulsory schools (i.e., clustering sampling). Before drawing the sample, we sorted the schools by province and by municipality or city in each province (i.e., implicitly stratified sampling). Thus, the sample was selected according to the ratio of schools in each province. Systematic sampling was

used to draw each $q$th school (sampling interval: $q = N/n$; $N$ = all schools, $n$ = selected schools) from this stratified list. The sample schools were in municipalities or cities of different sizes, and school sizes varied from small ($n = 65$) to large ($n = 658$). General and SEdS classes for eighth-grade students were selected from these schools. Small general classes ($n = 4$) with low mathematics performance were excluded.

The final number of students was 1379, distributed across 88 classes ($M = 15.67$, $SD = 5.25$) in 27 schools. The average class size was based on the participants. Of the participants, 73 (5.3%) received SEdS in self-contained mathematics classrooms, 127 (9.2%) received SEdS in general mathematics classrooms, and 1179 received no SEdS in mathematics. Notably, the percentage of adolescents receiving SEdS was close to the average in Finnish lower secondary schools (see Section 1.2). Of the 88 mathematics classrooms, 11 were self-contained SEdS types, and 77 were general types. Of the 77 general classrooms, 44 were general types with students receiving SEdS, and 33 were general types without students receiving SEdS. On average, two students per class received SEdS in general classrooms with students receiving SEdS ($M = 2.89$, $SD = 2.14$; minimum = 1, maximum = 10; median = 2). Table 1 shows the demographic data.

Section 1.2 provides detailed descriptions of the SEdS forms in mathematics. Students receiving SEdS in self-contained mathematics classrooms were taught by special education teachers in small, separate classrooms. Students receiving SEdS in general classrooms did so on a part-time ($n = 100$, 7.3%) or full-time basis ($n = 27$, 2.0%); these two groups did not differ significantly in mathematics-related achievement emotions, $F(7, 119) = 1.55$, $p = .20$, Wilks' lambda = 0.92. Teachers reported that students received part-time SEdS for about 1 h per week in small groups in resource rooms and were otherwise in general classrooms (about 3 h per week). Students receiving SEdS in self-contained classrooms had mathematics difficulties. Students receiving SEdS in general classrooms had milder problems with the subject. Teachers did not report any students with emotional problems.

Table 1 shows the means and standard deviations of the mathematics performance across the study groups, measured by the test used to identify mathematics difficulties (see Section 2.2.2). A univariate analysis of variance showed the main effect of the study groups on mathematics performance, $F(2, 1320) = 162.51$, $p < .001$, $\eta_p^2 = 0.20$. The Scheffe post-hoc test revealed that students receiving SEdS in self-contained classrooms had lower mathematics performance than those receiving SEdS in general classrooms ($p < .01$, Cohen's $d = 0.53$) and those receiving no SEdS ($p < .001$, $d = 1.72$). Students receiving SEdS in general classrooms had lower mathematics performance than students receiving no SEdS ($p < .001$, $d = 1.27$).

## 2.2. Measures

### 2.2.1. Mathematics-related achievement emotions

The Achievement Emotions Questionnaire-Mathematics (AEQ-M; Pekrun et al., 2005) was used to assess trait achievement emotions in mathematics. The AEQ-M, a self-reported instrument, contains 60 items measuring enjoyment, pride, anger, anxiety, shame, hopelessness, and boredom in relation to the mathematics classroom, learning, and testing. Respondents were asked to express emotions on a five-point Likert scale. The AEQ-M's ordinary English version (Pekrun et al., 2005) was translated into Finnish by a bilingual expert and then pilot tested in a Finnish school. Thirty students from two classes and 10 students receiving SEdS completed the pilot questionnaire and offered feedback. No negative feedback regarding the AEQ-M's language and structure was reported, and the students reported understanding the questionnaire. This study used 52 AEQ-M items measuring mathematic-related enjoyment (10 items, e.g., enjoyment in class), pride (five items, e.g., pride after a test), anger (nine items, e.g., anger because of homework), anxiety (nine items, e.g., too anxious to take a test), shame (seven items, e.g., shame after a test), hopelessness (six items, e.g., hopelessness during a test), and boredom (six items, e.g., boredom during homework).

We eliminated eight of the original 60 items, as confirmatory factor analysis (CFA) showed poor model fit for anxiety, shame, and pride (comparative fit index [CFI] $< 0.88$; root mean square error of approximation [RMSEA] $> 0.10$; see Section 2.4.2). High modification indices (Byrne, 2012) suggested high correlations between similarly worded emotion item residuals related to the same situations (classroom, learning, and testing). These correlations were in line with AEQ-M models, including correlations between all item residuals representing the same situations (Pekrun et al., 2019). To avoid excessive statistical model complexity, we excluded the other correlated item. After removing the eight items, the model fits for all emotions were acceptable (see Appendix A). The reliability of the AEQ-M scales ranged from good ($0.8 \leq$ Cronbach's $\alpha < 0.9$) to excellent ($\alpha \geq 0.9$). Notably, the results did not differ from the results obtained by analyzing the original AEQ-M.

### 2.2.2. Mathematics performance

A Finnish standardized test of mathematics skills (KTLT; Räsänen & Leino, 2005) was used to assess performance. The test is normed to be reliable for Grades 7–9 and is used to screen mathematics difficulties. The KTLT assesses core mathematics skills, including arithmetic, word problems, algebra, geometry, and unit conversion. Widely used in Finland, this test has shown good internal reliability (e.g., Korhonen, Linnanmäki, & Aunio, 2014) and good criterion validity with other measures of mathematics performance (Räsänen & Leino, 2005). The KTLT is a paper-and-pencil test consisting of 40 items, with 1 point for a correct answer and 0 for an incorrect answer (the maximum is 40 points). Of the four versions (A to D), B was chosen because of its reported highest internal reliability ($\alpha = 0.90$; Räsänen & Leino, 2005). In this study, the KTLT had good reliability ($\alpha = 0.89$).

## 2.3. Procedure

The assessment was completed in spring 2010. The study materials

**Table 1**
Demographic data across special education support (SEdS) groups.

| Student level | SEdSSeg | SEdSGen | Without |
|---|---|---|---|
| Students, *n* | 73 | 127 | 1,179[a] |
| Girls, *n* | 35 | 60 | 626 |
| Math score, *M*(*SD*) | 12.81(6.25) | 15.99(5.79) | 24.00(6.75) |
| Classroom level | Self-contained class | General class with SEdS | General class without SEdS |
| Classrooms, *n* | 11 | 44 | 33 |
| Average class size, *M*(*SD*) | 6.64(2.38) | 17.39(4.53) | 16.39(3.77) |
| Class-average math score, *M*(*SD*) | 12.57(3.59) | 22.49(2.98) | 23.91(3.27) |

*Note*. SEdSSeg = receiving SEdS in self-contained mathematics classrooms; SEdSGen = receiving SEdS in general mathematics classrooms; Without = receiving no SEdS in mathematics.

[a] Of those receiving no SEdS, 638 were in classes with students receiving SEdS and 541 were classes without students receiving SEdS.

were sent to the schools by regular mail. We followed the Finnish ethical principles of research in the humanities and social and behavioral sciences (National Advisory Board on Research Ethics, 2009). According to these principles, this study did not involve any of the circumstances that would require an ethics review. Permission for the study was obtained from municipal education departments and head teachers, and students' parents provided informed consent. We excluded 10 participants from different classrooms who did not provide consent.

Detailed instructions for teachers were provided separately and in the test material. In the feedback, the teachers reported that the implementation of the study was clear. The students were given 30 min to complete the AEQ-M at the end of a mathematics lesson. We instructed the teachers to read the AEQ-M instructions aloud. Before administration of the AEQ-M, the students were assured that their responses were confidential, asked to express their personal opinions, and informed that there were no right or wrong answers. On the questionnaire, items were presented in three sections: class-related, learning-related, and test-related emotions. Each section comprised items pertaining to emotions before, during, and after the situation. During another lesson, the KTLT was administered, and the students had 40 min to complete it. After all the measures were completed, the teachers collected all the materials and returned them to the researchers by regular mail.

### 2.4. Data analysis

#### 2.4.1. Missing values

The missing data from the AEQ-M (0.5%) were imputed in SPSS (version 25) using expectation-maximization algorithm (Dempster, Laird, & Rubin, 1977). Other AEQ-M items served as auxiliary variables to impute the missing item values. Forty-nine students receiving no SEdS and only six students receiving SEdS in general classrooms were excluded from the analysis because they did not complete the KTLT.

#### 2.4.2. Model fit indices

We used chi-square ($\chi^2$) and the CFI, Tucker–Lewis index (TLI), and RMSEA. CFI and TLI values > 0.90 and 0.95 reflect acceptable and excellent model fits. RMSEA values < 0.05 and 0.08 reflect close and reasonable model fits (Marsh, Hau, & Wen, 2004). Composite reliability (Geldhof, Preacher, & Zyphur, 2014) was calculated to measure the internal consistency reliability of the emotion factors.

#### 2.4.3. Measurement invariance

Using the Mplus statistical package (version 7; Muthén & Muthén, 1998–2013), we tested whether the measures were invariant across the three SEdS groups (i.e., receiving no SEdS and receiving SEdS in general and self-contained classrooms). All models were estimated with the robust maximum likelihood estimator (MLR), as it is robust to non-normality of the observed variables. Measurement invariance assesses the equivalence of latent emotion constructs across SEdS groups. Multiple-group CFA was used to test measurement invariance by specifying a series of nested models for each achievement emotion. In this analysis, the endpoints constitute the least restrictive model with no invariance constraints, and the most restrictive model constrains all parameters to be the same across all groups (Bollen, 1989). According to Chen (2007), support for the more parsimonious model requires a change in the CFI (ΔCFI) value of < 0.01 or a change in the RMSEA (ΔRMSEA) value of < 0.015. The Bayesian information criterion (BIC) was also used to compare models. Models with a larger BIC show a poorer fit (van de Schoot, Lugtig, & Hox, 2012).

#### 2.4.4. Structural equation modeling

We used structural equation modeling (SEM) to investigate whether students receiving SEdS in self-contained classrooms differ in emotions from students receiving and not receiving SEdS in general classrooms (RQ1). We used SEM rather than multilevel modeling (MLM), as students receiving SEdS in self-contained classrooms formed their own classes and were not nested in general classrooms (Marsh et al., 2009). The latent KTLT[2] and gender were controlled for. All SEM models were estimated with the MLR in Mplus. We specified models in which two dummy-coded SEdS groups (in self-contained or general classrooms), the KTLT, and the dummy-coded gender (1 = boys) predicted each emotion. The group receiving SEdS in self-contained classrooms was the reference group. We reported standardized regression coefficients (β; interpreted as the effect size; Lorah, 2018).

#### 2.4.5. Multilevel modeling

We used MLM to investigate whether adolescents receiving SEdS in general classrooms differ in emotions from those receiving no SEdS at the individual level (RQ2) and whether the proportion of students receiving SEdS has contextual effects on the achievement emotions of those receiving no SEdS (RQ3). We controlled for the effects of gender and KTLT at the individual and classroom levels and for class size at the classroom level. All MLM models were estimated with the MLR in Mplus. In each analysis, we used separate emotion models because the number of parameters was higher in the seven-factor model than the number of classes. It is advisable to have more clusters than parameters in MLM (Muthén, 2008). All models were doubly latent types, in which latent individual-level variables, including achievement emotions (dependent variable) and KTLT (predictor), were modeled as latent constructs at the classroom level (i.e., latent aggregation; Marsh et al., 2009). We used the doubly latent approach because it accounted for sampling and measurement errors. The models also contained manifest individual-level predictors, including SEdS group and gender, which were aggregated at the classroom level (i.e., manifest aggregation; Marsh et al., 2009).

In the preliminary analysis, we first tested separate, fully unconditional models in which latent emotion constructs were defined at the individual and classroom levels. The classroom-level factor loadings were constrained to be equal to the individual-level factor loadings; this reduced the estimated parameters, and there was no substantial loss of fit between constrained and unconstrained models. To determine whether MLM was required, the intraclass correlations (ICCs; Garson, 2013) that estimated the proportion of variance between classrooms were determined for each emotion. Classroom-level analyses are warranted if the ICC is approximately 0.05 or higher (LeBreton & Senter, 2008).

In the main analysis, we implemented several multilevel models to investigate RQ2 and RQ3. We specified the models in which the dummy-coded SEdS group in general classroom, dummy-coded gender, and latent KTLT predicted each emotion at the individual level. The proportion of students receiving SEdS in general classrooms, gender proportion, latent aggregated KTLT, and classroom size were classroom-level predictors. The group receiving no SEdS was the reference group at the individual and classroom (aggregated) levels. All general classrooms were included in the models; the proportion of students receiving SEdS varied between 0% and 57.14%.

Centering individual-level predictor variables is crucial in MLM (Lüdtke, Robitzsch, Trautwein, & Kunter, 2009). Latent KTLT indicators are grand-mean centered in the doubly latent model, causing independent effects at the classroom level (Marsh et al., 2009). The individual-level dummy predictors (SEdS group and gender) are group-mean centered (i.e., centering within cluster; Enders & Tofighi, 2007), causing independent effects at the classroom level. As applying group-mean centering to dummy variables yields the same interpretation as the continuous case (Enders & Tofighi, 2007), we used this centering approach to determine contextual effects (Marsh et al., 2009). A parameter, the contextual effect, was constructed using the model constraint command in Mplus. The contextual effect is present if the classroom-level effect of the proportion of students receiving SEdS is significantly

[2] The KTLT is a one-factor model in which standardized arithmetic, word problems, algebra, geometry, and unit conversion scales are indicators (CFI > 0.98; RMSEA < 0.05).

**Table 2**
Testing measurement invariance for mathematics-related achievement emotions across special education support (SEdS) groups.

| Models | $\chi^2$ | *df* | CFI | TLI | RMSEA | Models | \|ΔCFI\| | \|ΔRMSEA\| | BIC |
|---|---|---|---|---|---|---|---|---|---|
| Enjoyment | | | | | | | | | |
| 1. Configural | 305.34*** | 105 | 0.942 | 0.926 | 0.064 | | | | 35,222.80 |
| 2. Metric | 329.79*** | 123 | 0.940 | 0.935 | 0.060 | 1 vs. 2 | 0.002 | 0.004 | 35,122.61 |
| 3. Scalar | 361.62*** | 141 | 0.936 | 0.939 | 0.058 | 2 vs. 3 | 0.004 | 0.002 | 35,036.25 |
| Pride | | | | | | | | | |
| 1. Configural | 58.15*** | 15 | 0.954 | 0.910 | 0.079 | | | | 19,745.96 |
| 2. Metric | 81.17*** | 23 | 0.953 | 0.940 | 0.074 | 1 vs. 2 | 0.001 | 0.005 | 19,695.76 |
| 3. Scalar | 100.01*** | 31 | 0.944 | 0.945 | 0.070 | 2 vs. 3 | 0.009 | 0.004 | 19,666.59 |
| Anger | | | | | | | | | |
| 1. Configural | 286.37*** | 81 | 0.933 | 0.911 | 0.074 | | | | 35,380.76 |
| 2. Metric | 313.13*** | 97 | 0.929 | 0.921 | 0.070 | 1 vs. 2 | 0.004 | 0.004 | 35,305.53 |
| 3. Scalar | 336.92*** | 113 | 0.927 | 0.930 | 0.066 | 2 vs. 3 | 0.002 | 0.004 | 35,217.23 |
| Anxiety | | | | | | | | | |
| 1. Configural | 273.31*** | 81 | 0.925 | 0.900 | 0.072 | | | | 33,680.66 |
| 2. Metric | 302.17*** | 97 | 0.919 | 0.910 | 0.068 | 1 vs. 2 | 0.006 | 0.004 | 33,596.73 |
| 3. Scalar | 344.40*** | 113 | 0.910 | 0.913 | 0.067 | 2 vs. 3 | 0.009 | 0.001 | 33,539.74 |
| Shame | | | | | | | | | |
| 1. Configural | 113.01*** | 42 | 0.952 | 0.930 | 0.061 | | | | 25,077.68 |
| 2. Metric | 122.06*** | 54 | 0.954 | 0.946 | 0.052 | 1 vs. 2 | 0.002 | 0.009 | 24,998.46 |
| 3. Scalar | 136.34*** | 66 | 0.953 | 0.955 | 0.048 | 2 vs. 3 | 0.001 | 0.004 | 24,925.87 |
| Hopelessness | | | | | | | | | |
| 1. Configural | 103.42** | 27 | 0.965 | 0.942 | 0.079 | | | | 22,749.30 |
| 2. Metric | 127.95*** | 37 | 0.958 | 0.949 | 0.073 | 1 vs. 2 | 0.007 | 0.006 | 22,720.40 |
| 3. Scalar | 150.37*** | 47 | 0.953 | 0.955 | 0.069 | 2 vs. 3 | 0.005 | 0.004 | 22,677.92 |
| Boredom | | | | | | | | | |
| 1. Configural | 44.94* | 27 | 0.993 | 0.988 | 0.038 | | | | 23,859.82 |
| 2. Metric | 59.41* | 37 | 0.991 | 0.989 | 0.036 | 1 vs. 2 | 0.002 | 0.002 | 23,801.12 |
| 3. Scalar | 79.21* | 47 | 0.987 | 0.988 | 0.039 | 2 vs. 3 | 0.004 | 0.003 | 23,751.83 |

*Note.* *df* = degree of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation; BIC = Bayesian information criterion.
* $p < .05$.
** $p < .01$.
*** $p < .001$.

different from the corresponding individual-level effect. This significant contextual effect indicates that the classroom-level proportion of students receiving SEdS is associated with students' emotions at the individual level beyond what can be explained by individual-level effects. To test whether the effect of the proportion of SEdS is more related to students receiving no SEdS, we specified a cross-level interaction effect between the proportion of students receiving SEdS at the classroom level and students receiving SEdS at the individual level, using random-slope models (Marsh et al., 2009). The contextual effects and random-slope models were based on unstandardized regression coefficients; thus, only unstandardized regression coefficients are reported.

## 3. Results

### 3.1. Preliminary analysis

Measurement invariance across the SEdS groups was tested separately for achievement emotions. Table 2 shows the model fit indices from the measurement invariance tests. First, we specified the configural models of achievement emotions, imposing no invariance constraints on the factor loadings and indicator intercepts but assuming the same factor structure in the SEdS groups. We used this set of configural models as a baseline for testing measurement invariance. All configural models showed a good model fit. Second, we fitted metric invariance models where the factor loadings were constrained to equality across the groups. All metric invariance models indicated a good model fit and did not worsen the model fit (ΔCFI $< 0.01$, ΔRMSEA $< 0.015$). BIC was lower in all metric models than in the configural models. Third, we compared the metric invariance models against the scalar invariance models, in which we constrained the indicator intercepts to equality. All scalar invariance models showed good model fit and did not worsen the model fit (ΔCFI $< 0.01$, ΔRMSEA $< 0.015$). BIC was lower in all the scalar models than in the metric models. To conclude, latent emotions showed strong measurement invariance across the SEdS groups.

The separate unconditional models of emotions all showed good model fits, and the composite reliabilities for the factors were good at the individual and classroom levels (see Table 3). The between-class variances differed significantly from zero for all seven latent emotions. As Table 3 shows, the acceptable ICC ($\geq 0.05$, a small to medium effect) warranted analyses at the classroom level (LeBreton & Senter, 2008).

**Table 3**
Unconditional models of mathematics-related achievement emotions.

| Emotions | $\chi^2$ | *df* | TLI | CFI | RMSEA | ICC | CR *w/b* |
|---|---|---|---|---|---|---|---|
| Enjoyment | 391.62*** | 79 | 0.95 | 0.94 | 0.06 | 0.11 | 0.89/0.99 |
| Pride | 116.67*** | 14 | 0.95 | 0.93 | 0.07 | 0.05 | 0.80/0.93 |
| Anger | 429.08*** | 62 | 0.93 | 0.92 | 0.07 | 0.07 | 0.89/0.97 |
| Anxiety | 363.90*** | 62 | 0.93 | 0.92 | 0.06 | 0.05 | 0.87/0.95 |
| Shame | 130.84*** | 34 | 0.96 | 0.95 | 0.05 | 0.05 | 0.80/0.95 |
| Hopelessness | 182.73*** | 23 | 0.96 | 0.95 | 0.07 | 0.05 | 0.89/0.97 |
| Boredom | 64.70*** | 23 | 0.99 | 0.98 | 0.04 | 0.05 | 0.86/0.91 |

*Note.* *df* = degree of freedom; TLI = Tucker–Lewis index; CFI = comparative fit index; RMSEA = root mean square error of approximation; ICC = intraclass coefficient; CR = composite reliability; *w/b* = within/between levels.
*** $p < .001$.

**Table 4**
Comparing group receiving SEdS in self-contained classrooms with groups receiving SEdS in general classrooms and receiving no SEdS, controlling for mathematics performance and gender.

| | Enjoyment | Pride | Anger | Anxiety | Shame | Hopelessness | Boredom |
|---|---|---|---|---|---|---|---|
| | β(*se*) | β(*se*) | β(*se*) | β(*se*) | β(*se*) | β(*se*) | β(*se*) |
| SEdSGen | −0.26(0.04)*** | −0.34(0.04)*** | 0.24(0.05)*** | 0.29(0.05)*** | 0.21(0.05)*** | 0.31(0.04)*** | 0.17(0.05)** |
| Without | −0.19(0.05)*** | −0.23(0.05)*** | 0.10(0.05)* | 0.12(0.04)** | 0.09(0.05) | 0.15(0.04)*** | 0.08(0.05) |
| Math | 0.35(0.03)*** | 0.47(0.03)*** | −0.29(0.03)*** | −0.30(0.03)*** | −0.28(0.04)*** | −0.35(0.03)*** | −0.18(0.04)*** |
| Gender | 0.07(0.03)* | 0.11(0.03)*** | 0.05(0.03) | −0.01(0.03) | 0.01(0.03) | −0.09(0.03)*** | −0.03(0.03) |
| $R^2$ | 0.15(0.02)*** | 0.28(0.03)*** | 0.12(0.02)*** | 0.14(0.02)*** | 0.10(0.02)*** | 0.18(0.02)*** | 0.04(0.01)** |

*Note*. SEdSGen = receiving SEdS in general mathematics classrooms; Without = receiving no SEdS in general classrooms; β = standardized regression coefficient; *se* = standard error; $R^2$ = explained variance. The group receiving SEdS in self-contained classrooms was set as the reference group. Analysis was done using structural equation modeling.

* $p < .05$.
** $p < .01$.
*** $p < .001$.

### 3.2. Main results

#### 3.2.1. Research question 1

Table 4 shows the SEM results. Appendix B presents the means and standard deviations of emotions across the SEdS groups. The results showed that adolescents receiving SEdS in general classrooms reported significantly less enjoyment (β = −0.26) and pride (β = −0.34) and more anger (β = 0.24), anxiety (β = 0.29), shame (β = 0.21), hopelessness (β = 0.31), and boredom (β = 0.17) than those receiving SEdS in self-contained classrooms. Adolescents receiving no SEdS reported significantly less enjoyment (β = −0.19) and pride (β = −0.23) and more anger (β = 0.10), anxiety (β = 0.12), and hopelessness (β = 0.15) but not less shame and boredom than adolescents receiving SEdS in self-contained classrooms. Regarding the control variables (see Table 4), the KTLT had significant strong effects on all emotions. Gender had significant effects on enjoyment, pride, and hopelessness (boys reported more pleasant emotions).

#### 3.2.2. Research questions 2 and 3

The MLM results are presented in Table 5. Appendix B shows correlations between the variables used in the MLM. At the individual level, students receiving SEdS in general classrooms reported less enjoyment ($b = -0.28$) and pride ($b = -0.49$) and more anger ($b = 0.35$), anxiety ($b = 0.33$), shame ($b = 0.18$), hopelessness ($b = 0.43$), and boredom ($b = 0.23$) than those receiving no SEdS. Regarding the individual-level control variables (see Table 5), the KTLT had significant strong effects on all emotions. Gender had significant effects on enjoyment, pride, and hopelessness (boys reported more pleasant emotions).

At the classroom level, the proportion of students receiving SEdS in general classrooms was significantly related to class-average enjoyment ($b = -0.66$), pride ($b = -0.76$), anger ($b = 0.79$), anxiety ($b = 0.78$), shame ($b = 0.50$), hopelessness ($b = 0.96$), and boredom ($b = 0.76$). Thus, on average, more unpleasant mathematics-related emotions were reported in general classrooms with higher proportions of students receiving SEdS.

The contextual effects on emotions were present if the effects of the classroom-level proportions of students receiving SEdS were significantly different from the corresponding individual-level effects. As shown in Table 5, this was evident for anxiety, hopelessness, and boredom. Specifically, the classroom-level proportions of students receiving SEdS had significant contextual effects on students' anxiety ($b = 0.45$), hopelessness ($b = 0.53$), and boredom ($b = 0.53$) at the individual level. Thus, adolescents reported more anxiety, hopelessness,

**Table 5**
Effect of group receiving special education support (SEdS) in general classrooms on mathematics-related achievement emotions at individual and classroom levels when mathematics performance, gender, and classroom size are controlled for.

| | Enjoyment | Pride | Anger | Anxiety | Shame | Hopelessness | Boredom |
|---|---|---|---|---|---|---|---|
| | *b*(*se*) | *b*(*se*) | *b*(*se*) | *b*(*se*) | *b*(*se*) | *b*(*se*) | *b*(*se*) |
| Individual | | | | | | | |
| SEdSGen | −0.28(0.09)** | −0.49(0.10)*** | 0.35(0.10)** | 0.33(0.09)*** | 0.18(0.07)* | 0.43(0.11)*** | 0.23(0.10)* |
| Math | 0.46(0.05)*** | 0.78(0.08)*** | −0.31(0.05)*** | −0.28(0.04)*** | −0.21(0.03)*** | −0.43(0.04)*** | −0.21(0.05)*** |
| Gender | 0.09(0.06) | 0.22(0.07)** | 0.07(0.06) | −0.01(0.04) | −0.00(0.04) | −0.17(0.05)** | −0.06(0.05) |
| $R^2$ | 0.14(0.02)*** | 0.28(0.03)*** | 0.08(0.02)*** | 0.11(0.02)*** | 0.09(0.02)*** | 0.15(0.02)*** | 0.04(0.01)** |
| Classroom | | | | | | | |
| SEdSGen_P | −0.66(0.28)* | −0.76(0.28)** | 0.79(0.25)** | 0.78(0.20)*** | 0.50(0.18)** | 0.96(0.26)*** | 0.76(0.22)*** |
| Math_A | 0.32(0.19) | 0.34(0.17)* | −0.37(0.14)* | −0.24(0.09)** | −0.08(0.06) | −0.35(0.12) | −0.20(0.13) |
| Gender_P | 0.59(0.23)* | 0.44(0.23) | −0.08(0.18) | −0.03(0.12) | 0.09(0.10) | −0.07(0.17) | −0.32(0.18) |
| Class size | 0.01(0.01) | 0.00(0.01) | −0.01(0.01) | −0.00(0.00) | 0.01(0.00) | 0.00(0.01) | −0.00(0.01) |
| $R^2$ | 0.27(0.11)* | 0.49(0.18)** | 0.52(0.20)* | 0.75(0.17)*** | 0.61(0.27)* | 0.67(0.16)*** | 0.64(0.29)* |
| Contextual[a] | | | | | | | |
| SEdSGen_P | −0.38(0.26) | −0.27(0.29) | 0.44(0.23) | 0.45(0.20)* | 0.32(0.19) | 0.53(0.26)* | 0.53(0.22)* |

*Note*. SEdSGen = receiving SEdS in general mathematics classrooms; P = classroom-level proportion; A = classroom average; *b* = unstandardized regression coefficient; *se* = standard error; $R^2$ = explained variance. The group receiving no SEdS was set as the reference group. Analysis was done using multilevel modeling.

[a] Contextual effect is the difference between the unstandardized classroom-level regression coefficient and the individual-level regression coefficient.

* $p < .05$.
** $p < .01$.
*** $p < .001$.

and boredom in general classrooms when the proportion of adolescents receiving SEdS was higher. The cross-level interaction effects (classroom-level proportion × individual-level SEdS group) on anxiety, hopelessness, and boredom were not significant ($p > .05$). Thus, the proportion of students receiving SEdS in general classrooms related to anxiety, hopelessness, and boredom among students receiving no SEdS and receiving SEdS (the contextual effects were similar across the SEdS groups). Regarding the classroom-level control variables (see Table 5), class-average KTLT had a significant positive effect on class-average pride and negative effects on class-average anger and anxiety. A higher proportion of boys related positively to class-average enjoyment.

## 4. Discussion

This study was the first to investigate mathematics-related achievement emotions of adolescents receiving SEdS in self-contained and general classrooms and those receiving no SEdS. We controlled for mathematics performance and gender at the individual and classroom levels and for classroom size at the classroom level. We found that adolescents receiving SEdS in self-contained mathematics classrooms reported more enjoyment and pride and less anger, anxiety, shame, hopelessness, and boredom than those receiving SEdS in general classrooms and more positive and less negative emotions but not less shame and boredom than those receiving no SEdS. Contrarily, adolescents receiving SEdS in general classrooms reported less positive emotions and more negative emotions than those receiving no SEdS. Finally, the contextual effect revealed that adolescents receiving no SEdS reported more anxiety, hopelessness, and boredom when proportions of adolescents receiving SEdS were higher in general classrooms.

### 4.1. Emotions among students receiving SEdS

Our results support the first hypothesis that adolescents receiving SEdS in self-contained classrooms report more pleasant mathematics-related emotions, such as enjoyment, than adolescents receiving SEdS in general classrooms. We found that this was evident not only for positive emotions, including pride and enjoyment, but also for negative emotions, including anger, anxiety, shame, hopelessness, and boredom. While previous studies found that students receiving SEdS in self-contained classrooms reported more enjoyment and higher self-concept than those receiving SEdS in general classrooms (Kocaj et al., 2018; Szumski & Karwowski, 2015), our results indicated that this exists for several mathematics-related achievement emotions. Our results support the second hypothesis that adolescents receiving SEdS in self-contained mathematics classrooms report less mathematics-related anxiety than those receiving no SEdS. These results confirmed the previous findings that adolescents receiving SEdS in self-contained classrooms reported less anxiety than those receiving no SEdS (Wiest et al., 2001). We found that adolescents receiving SEdS in self-contained mathematics classrooms reported not only less anxiety but also less anger and hopelessness and more pride and enjoyment than those receiving no SEdS. In line with the third hypothesis, we found that adolescents receiving SEdS in general mathematics classrooms reported less mathematics-related pride and enjoyment and more anger, anxiety, shame, hopelessness, and boredom than those receiving no SEdS. Our results extend the previous findings that adolescents receiving SEdS in general classrooms reported less intrapersonal strength (Lappalainen et al., 2009) and more depression (Valås, 2001) than those receiving no SEdS.

Our results raise the question of why there are differences in mathematics-related emotions between adolescents receiving SEdS in self-contained and general classrooms and those receiving no SEdS. First, according to the BFLPE (Pekrun et al., 2019), adolescents receiving SEdS in general classrooms might experience more unpleasant emotions than other study groups as they study with and compare themselves with higher-performing classmates. Contrarily, adolescents receiving SEdS in self-contained classrooms might experience more pleasant emotions than other study groups because they compare themselves with lower-performing classmates. This positive BFLPE might even explain why they report more enjoyment and pride and less anxiety, anger, and hopelessness than adolescents receiving no SEdS when mathematics performance was controlled for. Second, adolescents receiving SEdS in small, self-contained classrooms might be subjected to expectations, receive instructions, and be assigned tasks and goals that match their capabilities, as well as receive personal support and positive feedback. Thus, they might experience more pleasant mathematics-related achievement emotions than other study groups, as stated by the control-value theory (Pekrun, 2006). These supportive mechanisms might not be comprehensively implemented in large, general mathematics classrooms. Therefore, adolescents receiving SEdS in general classrooms might experience more unpleasant mathematics-related achievement emotions than other study groups (Pekrun, 2006).

### 4.2. Contextual effect on emotions of adolescents receiving no SEdS

Our results confirmed the fourth hypothesis that the higher proportion of adolescents receiving SEdS in general classrooms has a contextual effect on boredom of classmates receiving no SEdS. We found that this was also evident for anxiety and hopelessness. Our results support the finding that students receiving no SEdS reported in interviews that they experienced boredom in inclusive classrooms (Litvack et al., 2011; Vaughn et al., 1995). These results suggest that boredom is a central emotion among students receiving no SEdS in inclusive classrooms. Our results extend the previous findings that the higher proportion of adolescents receiving SEdS in general classrooms related to lower academic performance of adolescents receiving no SEdS (Dyson et al., 2004; Hienonen et al., 2018). We found that adolescents receiving no SEdS in general classrooms reported more hopelessness, anxiety, and boredom when the proportion of classmates receiving SEdS was higher. Thus, adolescents receiving no SEdS in more inclusive classrooms (i.e., including more students receiving SEdS) reported more anxiety, hopelessness, and boredom than those receiving no SEdS in less inclusive classrooms.

Our results raise the question of why adolescents receiving no SEdS report such negative emotions in more inclusive classrooms. The control-value theory states that boredom is related to valueless and unchallenging activities (Pekrun, 2006). Perhaps the presence of adolescents receiving SEdS in general classrooms decreases learning demands, and adolescents receiving no SEdS are not assigned enough valuable and challenging mathematics activities (Litvack et al., 2011; Ruijs et al., 2010). Thus, they reported more boredom when the proportion of classmates receiving SEdS was higher in general classrooms. Previous findings showed that decreased teacher support was associated with adolescents' mathematics-related hopelessness and anxiety (Ahmed et al., 2010; Sakiz et al., 2012). Perhaps teachers lack the time to support adolescents receiving no SEdS in general classrooms when the proportion of classmates receiving SEdS is higher (Dyson et al., 2004); thus, adolescents receiving no SEdS report more hopelessness and anxiety. Notably, we also found that adolescents receiving SEdS reported more anxiety, hopelessness, and boredom when the proportion of classmates receiving SEdS was higher in general classrooms. The decreased support in more inclusive classrooms might also cause adolescents receiving SEdS to experience hopelessness and anxiety (Sakiz et al., 2012). Learning without support might be challenging for adolescents receiving SEdS; thus, they may experience boredom (related to challenging activities; Pekrun, 2006).

### 4.3. Limitations and future directions

We used a self-report measure to assess achievement emotions. Although this measure has shown good internal reliability in this and other studies (Pekrun et al., 2019; Sakiz et al., 2012), future studies could use other methods for analyzing achievement emotions (e.g.,

physiological measurement). We examined habitual trait achievement emotions, which are stable and are influenced by subjective beliefs (Pekrun, 2006; Robinson & Clore, 2002). Future research could examine whether the association is different between SEdS and momentary state achievement emotions. Although our results are partly in line with studies on emotions in SEdS settings, future research should examine achievement emotions and SEdS in relation to school subjects other than mathematics. Because a definitive causal conclusion about the relationship is impossible in this cross-sectional study, longitudinal and experimental studies are needed.

Students receiving SEdS in self-contained and general classrooms comprise challenging study groups due to modest sample size issues. However, the samples corresponded well to the actual occurrences (Statistics Finland, 2011). Because of the modest sample sizes, small effects regarding students receiving SEdS in self-contained and general classrooms might not be significant. However, we investigated achievement emotions in general classrooms using multilevel models that considered the nested data structure and controlled for measurement and sampling errors. Because students in Finland receive support according to SEdS needs in mathematics rather than diagnosis-based needs (FNBE, 2004, 2016), this study did not have comprehensive diagnostic information. As students were not randomly divided between general and self-contained classrooms, students with severe difficulties could be placed in self-contained classrooms. Although we controlled for mathematics performance, differences in metacognition and self-awareness might affect the emotions reported. However, the AEQ-M showed strong measurement invariance across the SEdS groups; these groups seemed to understand the AEQ-M similarly. Teachers reported that students receiving SEdS understood the questionnaire. Furthermore, students receiving mathematics SEdS in self-contained classrooms were from general schools and might be integrated into other subjects. Thus, the variation in background characteristics, such as cognitive abilities between students in self-contained versus general classrooms, might be negligible.

Previous studies have suggested that gender and academic performance should be controlled for when investigating achievement emotions and SEdS (Ahmed et al., 2010; Kocaj et al., 2018; Lazarides & Buchholzb, 2019); we have done this in our study. However, the control-value theory states that the control and value appraisals are the main antecedents of achievement emotions (Pekrun, 2006), and these appraisals have been found to predict achievement emotions over and above mathematics performance in single-level analyses (e.g., Henschel & Roick, 2017). Future studies should investigate whether our results, including the contextual effects, hold when controlling for control and value appraisals at the individual level. Generally, future studies could simultaneously investigate at the individual level affective, social, and cognitive variables among students receiving SEdS and consider mechanisms that might relate to these effects like BFLPE and stigma (Hannes et al., 2012; Kocaj et al., 2018). Future studies could also investigate whether the proportion of students receiving SEdS in general classrooms has contextual effects on several affective and social outcomes of students receiving no SEdS. Mechanisms that can explain the classroom-level effects, such as changes in learning demands (Litvack et al., 2011), could be considered.

### 4.4. Theoretical and practical implications

Our results have theoretical implications. The control-value theory determines that classroom settings relate to achievement emotions (Pekrun, 2017). Our results promote this theory by showing that SEdS settings are related to achievement emotions. Our results contribute to the theoretical framework of SEdS, which indicates that serving students receiving SEdS in self-contained classrooms might cause more positive affective outcomes than serving them in general classrooms (Kocaj et al., 2018; Szumski & Karwowski, 2015). Our results suggest this link for several achievement emotions.

Regarding practical implications, our results suggest that supporting students receiving SEdS in self-contained classrooms enhances their pleasant achievement emotions more than supporting them in general classrooms. Thus, to implement global inclusion (UNESCO, 2009), educators and policy makers should develop practical solutions that support achievement emotions in inclusive classrooms. First, teachers could give individualized feedback (not in relation to higher-performing classmates) and instruction (e.g., individualized materials) to students receiving SEdS in inclusive classrooms, because this might reduce students' self-comparison with higher-performing classmates and, thus, increase their pleasant emotions (BFLPE; Pekrun et al., 2019; Roy, Guay, & Valois, 2015). Second, teachers could use self-monitoring techniques (Rock, 2005) to support adolescents receiving SEdS to control and recognize their appraisals and emotions by transforming them into pleasant ones (Pekrun, 2006). Third, additional support, such as coteaching and assistance, could be used to support emotions of students receiving SEdS, because increased personal and emotional support is related to pleasant achievement emotions (Sakiz et al., 2012). This additional support might give teachers more time to help students receiving no SEdS in inclusive classrooms; thus, they would experience less anxiety and hopelessness (Sakiz et al., 2012). Fourth, differentiated instruction that matches students' abilities may allow all students to experience appropriate challenges in inclusive classrooms (Lawrence-Brown, 2004); thus, adolescents receiving and not receiving SEdS might experience less boredom, hopelessness, and anxiety (Pekrun, 2006). However, teachers might need additional resources and training to implement practical implications in inclusive classrooms (UNESCO, 2009).

To conclude, inclusion in general classrooms may not be fully functional to support the achievement emotions of adolescents receiving and not receiving SEdS. Future research should continue to explore various achievement emotions among all students in inclusive classrooms and examine whether the suggested practical implications support students' achievement emotions in inclusive classrooms.

## Appendix A. The goodness-of-fit statistics for mathematics-related achievement emotions observed in confirmatory factor analysis

| Models | Items | $\chi^2$ | df | CFI | TLI | RMSEA |
|---|---|---|---|---|---|---|
| Enjoyment | 10 | 303.85*** | 35 | 0.95 | 0.93 | 0.075 |
| Pride | 5 | 48.23*** | 5 | 0.96 | 0.92 | 0.079 |
| Anger | 9 | 259.38*** | 27 | 0.94 | 0.92 | 0.079 |
| Anxiety | 9 | 225.67*** | 27 | 0.93 | 0.91 | 0.073 |
| Hopelessness | 6 | 75.35*** | 9 | 0.97 | 0.94 | 0.073 |
| Shame | 7 | 74.19*** | 14 | 0.96 | 0.94 | 0.056 |
| Boredom | 6 | 30.14*** | 9 | 0.99 | 0.99 | 0.041 |

*Note*. *df* = degree of freedom; CFI = comparative fit index; TLI = Tucker–Lewis index; RMSEA = root mean square error of approximation.
*** $p < .001$.

## Appendix B. Descriptive statistics for SEdS groups on mathematics-related achievement emotions

| | Not controlling for math and gender | | | Controlling for math and gender | | |
|---|---|---|---|---|---|---|
| | SEdSSeg | SEdSGen | Without | SEdSSeg | SEdSGen | Without |
| | *M*(*SD*) | *M*(*SD*) | *M*(*SD*) | *M*(*SD*) | *M*(*SD*) | *M*(*SD*) |
| Enjoyment | 2.50(0.80) | 1.94(0.66) | 2.52(0.76) | 2.88(0.76) | 2.19(0.77) | 2.47(0.76) |
| Pride | 2.97(0.90) | 2.29(0.71) | 3.00(0.85) | 3.43(0.85) | 2.58(0.86) | 2.95(0.82) |
| Anger | 2.15(0.86) | 2.80(0.98) | 2.07(0.88) | 1.84(0.92) | 2.57(0.94) | 2.11(0.89) |
| Anxiety | 2.03(0.75) | 2.59(0.85) | 1.93(0.74) | 1.75(0.77) | 2.40(0.79) | 1.96(0.76) |
| Shame | 1.71(0.66) | 2.09(0.78) | 1.63(0.66) | 1.50(0.69) | 1.94(0.70) | 1.65(0.69) |
| Hopelessness | 2.09(0.85) | 2.95(1.13) | 2.02(0.95) | 1.70(0.97) | 2.70(0.98) | 2.06(0.93) |
| Boredom | 2.45(1.01) | 2.90(1.01) | 2.41(0.93) | 2.25(0.96) | 2.75(1.00) | 2.44(0.99) |

*Note*. SEdSSeg = receiving SEdS in self-contained mathematics classrooms; SEdSGen = receiving SEdS in general mathematics classrooms; Without = receiving no SEdS in general classrooms. The descriptive statistics are based on the manifest variables.

## Appendix C. The Pearson's Correlations between individual and classroom-level predictors on mathematics-related achievement emotions

| | Enjoyment | Pride | Anger | Anxiety | Shame | Hopelessness | Boredom |
|---|---|---|---|---|---|---|---|
| Individual | | | | | | | |
| SEdSGen | −0.22*** | −0.24*** | 0.24*** | 0.25*** | 0.20*** | 0.28*** | 0.15*** |
| Math | 0.37*** | 0.40*** | −0.30*** | −0.31*** | −0.24*** | −0.36*** | −0.18*** |
| Gender | 0.09** | 0.08** | 0.02 | −0.06* | 0.02 | −0.11*** | −0.05 |
| Classroom | | | | | | | |
| SEdSGen_P | −0.28* | −0.28* | 0.43*** | 0.52*** | 0.47*** | 0.52*** | 0.35** |
| Math_A | 0.40*** | 0.44*** | −0.44*** | −0.45*** | −0.29* | −0.45*** | −0.29* |
| Gender_P | 0.22* | 0.18 | −0.07 | −0.07 | 0.09 | −0.03 | −0.18 |
| Class size | 0.14 | 0.13 | −0.15 | −0.07 | −0.04 | −0.08 | −0.04 |

*Note*. SEdSGen = receiving SEdS in general mathematics classrooms; P = classroom-level proportion; A = classroom average. The correlations are based on the manifest variables. At the classroom level, emotions are class-average emotions.

* $p < .05$.

** $p < .01$.

*** $p < .001$.

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